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MILLING AND BAKING TESTS OF WHEAT CONTAINING ADMIXTURES OF RYE, CORN COCKLE, KINGHEAD, AND VETCH.

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INTRODUCTION.

Wheat as grown and as marketed frequently contains various kinds of so-called inseparable impurities, such as rye (*Secale cereale*), corn cockle (*Agrostemma githago*), kinghead, or great ragweed (*Ambrosia trifida*), and wild vetch (*Vicia angustifolia*). These impurities are considered inseparable, inasmuch as they are not readily removed from wheat by the grain-cleaning machinery in general use in grain elevators and flour mills, because of their similarity in size, shape, and specific gravity to the wheat in which they occur.

Millers claim that the presence of these impurities in wheat in appreciable amounts injures the milling and baking qualities of the flour. The result is that wheat which contains a noticeable amount of these ingredients when marketed is generally penalized by being

Note.—The data presented in this bulletin are applicable to the wheat-producing sections of the United States and are of interest to farmers, grain dealers, flour millers, and bakers.

given a lower commercial grade or by a reduction in price, as compared with wheat that is free from such impurities. Special experiments to determine the effects that these impurities have on the milling and baking qualities of wheat were begun in 1912 by the Office of Grain Standardization and were continued in 1913 and 1914.

The results of milling and baking experiments with wheat containing various amounts of rye, corn cockle, kinghead, and vetch show conclusively that these impurities have detrimental effects on the quality of the flour.[1] Further experiments are planned with such impurities as rye, barley, wild oats, kafir, and wild-rose seed, and also with sprouted and bin-burnt wheat.

FREQUENCY OF OCCURRENCE OF IMPURITIES IN WHEAT.

A study of the analyses of samples of wheat secured from the crops of 1911, 1912, and 1913, as grown and as marketed, shows that a large percentage of the samples of spring and durum wheat contained rye, barley, oats, wild oats, corn cockle, kinghead, and wild-rose seed, and that wild vetch is sometimes found in appreciable amounts. Rye was found in 83.1 per cent of the hard winter-wheat samples secured. This information is given in Table I.

TABLE I.—*Wheat samples from the crops of 1911, 1912, and 1913, which contained certain impurities, showing the percentage of each impurity found.*

Impurities found.	Spring and durum wheat (633 samples).				Hard winter wheat (267 samples).			
	Samples containing impurities.	Percentage of total.	Percentage of impurity.		Samples containing impurities.	Percentage of total.	Percentage of impurity.	
			Average.	Maximum.			Average.	Maximum.
Barley	453	71.6	0.23	12.9	5	1.87	Trace.	0.1
Rye	249	39.2	.06	14.3	222	83.1	0.31	4.1
Oats	590	93.2	.33	6.8	63	23.6	.03	3.3
Wild oats	562	88.8	1.36	28.5	0	0	0	0
Corn cockle	375	59.2	.11	6.0	0	0	0	0
Kinghead	124	19.8	.09	3.8	0	0	0	0
Wild vetch	42	6.8	.10	3.8	0	0	0	0
Wild rose	209	33.0	Trace.	.8	15	5.6	Trace.	.1

COMPARISON OF THE SPECIFIC GRAVITY OF WHEAT AND OF ITS IMPURITIES.

The specific gravity of wheat varies with the type or class and also with the quality. The average specific gravity of a number of samples of soft wheat, determined in connection with investigations with grain, was 1.3891, with a range between 1.3616 and 1.4133,

[1] The writer is indebted to Levi M. Thomas, assistant in charge of the milling and baking investigation of the Office of Grain Standardization, who made all the baking and practical tests with the flour, assisted by W. K. Marshall, aid in grain standardization, and to Thomas Sanderson, in charge of the experimental mill of the North Dakota Agricultural College, who made the milling tests.

while the average specific gravity of a number of samples of hard wheat was 1.4273, the range being from 1.4152 to 1.4427.

Roberts[1] found a range in specific gravity between 1.227 and 1.386 in tests with 52 different types of wheat.

In his studies of various kinds of seeds Nobbe[2] gives the average specific gravity of 30 samples of wheat as 1.4131, with a variation between 1.3766 and 1.4396. The specific gravity of various other seeds is also given, viz, corn cockle (*Agrostemma githago*), 1.233; rye, for different tests, 1.325 and 1.371; barley, 1.351. The specific gravity of different species of vetch (Vicia) is given as follows: *Vicia benghalensis*, 1.344; *Vicia dumetorum*, 1.203; *Vicia faba*, 1.298; *Vicia lutea*, 1.273; *Vicia monanthos*, 1.327; *Vicia narbonensis*, 1.300.

Table II gives a comparison of the specific gravity of wheat with the specific gravity of several impurities very frequently found in wheat. These figures represent but one test of the impurities used in the milling and baking tests described in the following pages. It will be noted that the corn-cockle seed has a specific gravity nearly equal to that of wheat, while rye and hairy vetch have a greater specific gravity than wheat. The samples of rye, barley, kafir, and hairy vetch were cleaned with a small milling separator to remove any foreign matter, such as chaff or dirt, and the small and light kernels were also removed. The samples of rye and hairy vetch were possibly above the average quality. This is indicated by the test weight per bushel after the samples were cleaned. The rye weighed 58 pounds and the hairy vetch 64 pounds per bushel in comparison with 57 pounds per bushel, the test weight of the wheat used in the various tests with the different impurities. The kinghead seed, though having a smaller specific gravity than wheat, is somewhat larger and is not readily removed with ordinary mill cleaning machinery.

TABLE II.—*Specific gravity of wheat and of certain impurities frequently found.*

Wheat and impurity.	Sp. gr.	Impurity.	Sp. gr.	Impurity.	Sp. gr.	Impurity.	Sp. gr.
Wheat (spring)	1.3992	Barley	1.3425	Kafir	1.3175	Corn cockle	1.3915
Rye	1.4097	Wild oats	1.3320	Kinghead	.9563	Hairy vetch	1.4888

Figure 1 shows the comparative size and shape of wheat and rye kernels and of seeds of corn cockle, hairy vetch, kinghead, and wild vetch.

METHODS OF PREPARATION AND MILLING.

To insure greater uniformity in the different tests, a sufficient quantity of wheat of one variety was purchased each year to make all the milling tests desired. Thus, the samples milled and used as

[1] Roberts, H. F. Breeding for type of kernel in wheat. Kans. Agr. Exp. Sta. Bul. 170, p. 108–114, 1910.
[2] Noble, Friedrich. Handbuch der Samenkunde, p. 315–319. Berlin, 1876.

checks in each experiment are comparable with the samples containing the different impurities.

The wheat used in the experiment was thoroughly cleaned and scoured before making up the milling samples containing the various admixtures of rye, corn cockle, kinghead, and hairy vetch. This was done because the samples were neither cleaned nor scoured after the mixing, since it was desired that a definite known percentage of any added impurity should go to the rolls for milling into flour, bran, and shorts.

Each sample milled consisted of 100 pounds, including the impurity (e. g., 99 pounds of wheat and 1 pound of corn-cockle seed; 98 pounds of wheat and 2 pounds of corn cockle seed, etc.). The samples were

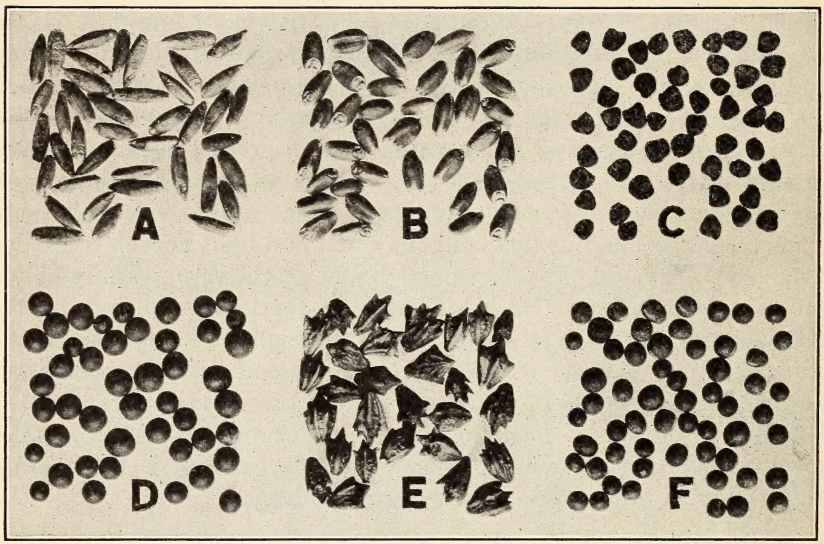

FIG. 1.—Grains of rye (*A*) and wheat (*B*); seeds of corn cockle (*C*), hairy vetch (*D*), kinghead (*E*), and wild vetch (*F*). On account of the shape, size, and specific gravity of these impurities they are not easily separated from wheat. (Natural size.)

milled at the North Dakota Agricultural College in the experimental mill, which has a capacity of 50 barrels per day of 24 hours.

To obtain results which would be comparable with average commercial conditions at country points, the methods of milling used in country mills were followed in general in the tests with the so-called inseparable impurities. The flour yields obtained compare very favorably with those secured by well-equipped country mills of 50 to 100 barrels daily capacity, since it was possible in milling the samples to make five breaks and as many reductions as desired, up to seven or eight.

In the tests covering the three years, the samples were milled as straight flours (that is, only one grade of flour was made from the

total flour obtained) and, in addition, in the 1913 tests, three grades of flour, viz, patent, first clear, and second clear, were made from wheat containing 10 per cent admixtures of rye, corn cockle, kinghead, and hairy vetch, in order to study the effects of a large percentage of these different impurities on each grade of flour.

In the 1912 and 1913 tests where the one grade (straight flour) was made, the percentages of impurities used in the admixtures were 1, 2, 3, 5, and 10, except that in the 1912 experiment with corn cockle tests were made with but 1, 2, and 3 per cent. In 1914 the milling tests were continued with samples of wheat with admixtures, viz, 1, 2, and 3 per cent each of corn cockle and kinghead, and 1, 2, 3, and 5 per cent of rye. No milling tests were made with admixtures of hairy vetch, as the experiments of 1912 and 1913 showed very conclusively the detrimental effects which this impurity has on the milling and baking qualities of wheat and flour.

Samples of wheat which contained large amounts of wild-vetch seed were secured by the writer from the 1914 crop as marketed by farmers at country points, and the results of the milling and baking tests of these samples are given in Table IX (p. 20). The results show that the detrimental effects of hairy vetch and of wild vetch in wheat as milled are very similar in character.

DESCRIPTIONS OF THE DIFFERENT IMPURITIES.

RYE.

Rye (*Secale cereale*) is the impurity most common and abundant in hard winter wheat. Millers object to its presence, claiming that it injures the color of the flour, but the opinions of millers differ greatly as to the amount of rye that may be present in wheat before the color of the flour will be affected. Some millers contend that 2 per cent of rye in wheat will injure the color of the flour, while others hold that amounts up to 5 per cent will not noticeably affect the quality of the flour or bread.

Rye was also found in 39.2 per cent of the spring-wheat samples secured, as indicated in Table I, and in one case the farmer's wheat crop contained 14.3 per cent. On account of the excessive amount of rye in this wheat the farmer received 8 cents less per bushel than he would have received had the grain been free from rye. The presence of rye in a considerable percentage of the samples examined was probably due to the fact that wheat containing rye was used for seeding purposes. Frequently wheat is sown on land which was planted in rye the previous season, and the rye shattered during harvest produces a volunteer crop which matures and is harvested with the wheat. Where the wheat crop partially winterkills, the percentage of rye is considerably increased, as rye is not so subject to

winterkilling as wheat. Baking tests with flour milled from wheat samples containing different percentages of rye showed detrimental effects on both the color and the texture of the crumb when above 3 per cent of this impurity was added to the wheat.

Examinations of samples of flour milled from wheat which contained various percentages of rye showed the presence of a considerable number of grayish and greenish yellow specks, especially in the samples containing more than 3 per cent of this ingredient.

Wheat containing a 3 per cent admixture of rye will yield a darker colored flour, showing quite distinctly toward the tail of the mill. When rye is milled alone about 48 per cent of flour is obtained, as shown in Table III (p. 10). Rye flour does not bolt freely, but when blended with wheat in small amounts it seems to cause very little trouble in bolting, since the wheat flour aids the rye flour in passing through the bolting cloth. The fact that the flour yield was but slightly reduced even in samples of wheat with 5 per cent

FIG. 2.—Wheat containing 6 per cent of corn-cockle seed and 8.7 per cent of other foreign matter, as delivered at a country elevator. (Natural size.)

or more of rye would indicate that a large proportion of the rye flour bolted through with the wheat flour. When wheat containing 10 per cent of rye was milled into three grades of flour, the injurious effects of rye were most pronounced in the second-clear flour, as evidenced in the baking results given in Table VI (p. 16).

CORN COCKLE.

Corn cockle (*Agrostemma githago*) is an annual prolific weed, the seed of which is rough, black, and of such a shape and size as to make it difficult to separate from wheat. It is very common, being widely distributed over the United States, and is especially abundant in the sections producing soft red winter, spring, and durum wheats. It is not an uncommon occurrence for wheat to contain 1 or 2 per cent of this weed seed, and occasionally 5 or 6 per cent of corn cockle is present in the grain as marketed (fig. 2). The presence of 1 or 2 per cent of corn cockle in wheat is likely to lower the grade or price given the farmer and will lower the baking qualities of the flour. The fact

that a single plant of corn cockle has been known to yield as high as 2,500 seeds shows it to be an exceedingly prolific and obnoxious weed, which every farmer should strive to eradicate or prevent from getting a start if the farm is not infested.

In milling wheat containing but 1 per cent of corn cockle, black specks, which are finely broken pieces of the outer covering of the seed, appear in the flour. When milled alone, corn-cockle seed will yield from 45 to 50 per cent of flour having a bluish white color and a specky appearance. Baking tests of three grades of flour milled from wheat containing 10 per cent of corn cockle indicated that this impurity was well distributed in each grade of flour (Table VI, p. 16).

Figure 2 represents a sample of spring wheat obtained by the writer from a farmer's wagon as the grain was unloaded at a country grain elevator. The mechanical analysis of this sample showed it to contain by weight 6 per cent of corn cockle, 1 per cent of wild buckwheat, and 7.7 per cent of other grains, which consisted of oats, wild oats, and barley.

The presence of such an amount (6 per cent) of corn cockle in this wheat resulted in a loss to the farmer, not only in the lower price per bushel which he received but in addition a dockage was assessed.

This term "dockage" is used with reference to the foreign matter present in wheat when marketed. It is the custom in the States producing spring wheat which contains a considerable quantity of foul weeds and other foreign matter to deduct from the gross weight of the load a certain amount expressed in pounds per bushel. For example, if a load of 50 bushels of wheat is found to contain 2 pounds of foreign matter for each bushel, then 100 pounds is deducted from the gross weight, and the owner of the grain receives pay for 50 bushels less the 100 pounds of dockage, or 48 bushels and 20 pounds of wheat.

KINGHEAD, OR GREAT RAGWEED.

Kinghead (*Ambrosia trifida*) is an annual weed belonging to the ragweed family, which grows very rank, from 3 to 15 feet high, in moist soil. Consequently, it is found more frequently and much more abundantly in river valleys and in sections where the ground lies low and where there is a good supply of moisture than in well-drained areas or sections with a light rainfall. According to Britton and Brown, this weed is widely distributed over the United States. However, it seems to be a greater pest in the Northwest, especially in Minnesota, North Dakota, and South Dakota, than in the other wheat-producing States.

On account of its shape and size (fig. 1) this seed, like corn cockle, is difficult to clean out of the wheat. One means of removing it, in

addition to the regular grain-cleaning machinery commonly found in mills, is that of floating it out with wheat washers, specially devised machines for cleaning smutty wheat. Since installing this equipment is expensive, few mills have such facilities, and they must depend on the ordinary grain cleaners, which remove but a small percentage of the kinghead seed, often present in quantities as high as 3 or 4 per cent. Unless wheat that contains large amounts of kinghead seed is mixed with a sufficient quantity of clean wheat to reduce the percentage of kinghead to a minimum, the flour produced will be of inferior quality. Such flour contains black specks, which injuriously affect the quality of the bread both in color and texture. The writer secured in a country mill samples of flour milled from wheat containing about 2 per cent of kinghead seed. Baking tests of these samples showed that both the color and the texture of the loaf were very seriously affected. When milled alone, kinghead seed

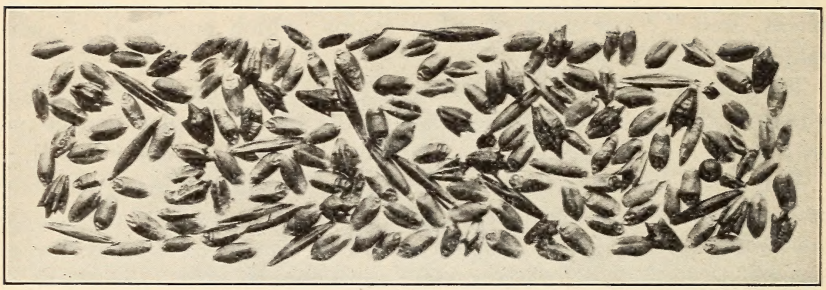

FIG. 3.—Wheat containing 28 per cent of kinghead seed and 3.5 per cent of other foreign matter, as unloaded from a wagon at a country elevator. (Natural size.)

gave a very low yield (less than 16 per cent) of flour, which was dark gray in color. The flour was readily reduced, the bulk of it being made on the break rolls and the first reduction. On account of the dark color of this flour, a mixture of 1 per cent of kinghead seed in wheat when milled is noticeable in the flour. When wheat containing 10 per cent of kinghead was milled into three grades of flour, the injurious effects of this so-called inseparable ingredient were in evidence in all grades, as shown by the results of the baking tests given in Table VI (p. 16).

Figure 3 shows a sample of spring wheat as grown and delivered to an elevator by a farmer. This sample contained 28 per cent of kinghead seed by weight, in addition to 2 per cent of rye and 1.5 per cent of wild oats. On account of the excessive amount of this practically inseparable weed seed in the wheat, the price and grade were greatly reduced, and, as with the sample which contained corn cockle, a heavy dockage was assessed by the grain buyer.

WILD VETCH.

Wild vetch (*Vicia angustifolia*) is a narrow-leaved species, closely related to common vetch, and is an annual weed growing about 1 to 2 feet high in fields and waste places. The seed is nearly round, black or dark brown in color, and, as a rule, fully as large as corn-cockle seed. For this reason it is difficult to separate it from wheat, and when present in appreciable quantities it lowers the grade and reduces the price given for the wheat. Although this weed is neither so prevalent nor so abundant as corn cockle, yet in some localities, especially in sections producing spring wheat, it is found in such amounts as to be a pest. The species of wild-vetch seed found in the wheat samples secured at country points consisted largely of the narrow-leaved vetch and to a lesser extent the hairy-pod vetch (*Vicia hirsuta*). The latter species has short pods covered with fine, short hairs (hence the

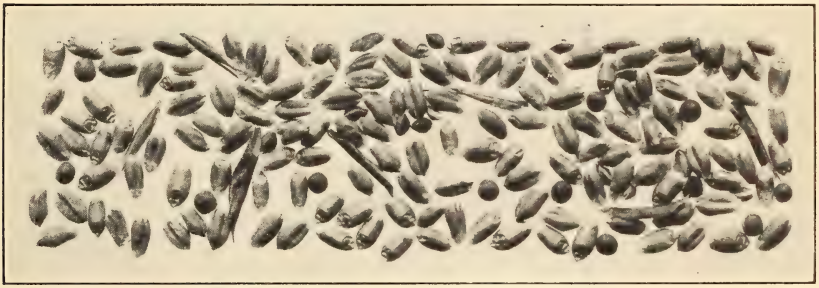

FIG. 4.—Wheat containing 3.8 per cent of wild-vetch seed and 1.5 per cent of other foreign matter, as unloaded from a farmer's wagon at a country elevator. (Natural size.)

name *hirsuta*), while the narrow-leaved vetch has black pods an inch or more in length.

Because it was not feasible to secure a sufficient amount of wild-vetch seed for use in the milling and baking tests which were made to study the effects of such an impurity in wheat, hairy-vetch seed (*Vicia villosa*), which is very similar in size and shape, was substituted for wild vetch. Hairy-vetch seed is less highly colored than seed of the wild vetch, which has a reddish orange-colored meat, and possibly the effect on the color of the crumb of the loaf was less pronounced than would have been the case if wild-vetch seed had been used. Where 1 per cent of hairy-vetch seed is present in wheat as ground, the flour will have a yellowish appearance and a noticeable odor of vetch. When milled alone, hairy-vetch seed gave a flour yield of about 58 per cent. It was hard to bolt, having a somewhat gummy consistency. The color of the flour was similar to that of powdered sulphur and consequently when blended with wheat flour it imparted a yellowish tint to the bread.

Figure 4 shows a sample of spring wheat containing 3.8 per cent of wild-vetch seed by weight, in addition to the other impurities, con-

sisting of 0.5 per cent of wild oats and 1 per cent of pigeon grass and other weed seed. This wheat was obtained from a farmer's wagon as the grain was unloaded at a country elevator. Because the grain buyer considered wild vetch an inseparable impurity which would injure the milling qualities of the wheat, the farmer was given a lower price for his grain than he would have received had the wheat been free from vetch seed.

COMPARATIVE MILLING YIELDS OF WHEAT AND OF ITS IMPURITIES.

Table III shows the yields of bran, shorts, and straight flour obtained in milling wheat in comparison with the yields of these products obtained in milling rye, corn cockle, kinghead, and hairy vetch as used in the milling and baking tests. Averages are given of three tests with wheat and corn cockle and of two tests with rye, kinghead, and hairy vetch.

TABLE III.—*Milling tests of wheat, rye, corn cockle, kinghead, and hairy vetch, showing comparative yields of straight flour, bran, and shorts.*

Ingredient.	Bran.	Shorts.	Straight flour.	Quantity milled.	Machine used in milling.	color of flour.
	Per cent.	*Per cent.*	*Per cent.*	*Pounds.*		
Wheat	12.5	14.7	71.4	120	50-barrel mill	White.
Rye	13.6	31.3	47.8	113	do	Gray.
Corn cockle	22.9	28.0	47.6	20	Small experimental mill	Bluish white.
Kinghead	52.3	31.9	15.8	5	do	Dark gray.
Hairy vetch	12.9	25.3	57.8	5	do	Yellow.

A relatively low yield of flour was secured when each impurity was milled by itself, especially in the test with kinghead seed, from which less than 16 per cent of flour was obtained. The presence of more than 1 per cent of this impurity in wheat as milled resulted in a noticeably decreased flour yield, as shown in Table IV.

Although the flour from each impurity was difficult to bolt when milled alone, when the mixtures of rye, corn cockle, and hairy vetch with wheat were milled the yield of flour was not greatly reduced. In all probability the wheat flour aided in bolting through a greater proportion of the flour from each of the impurities. On account of the decidedly different color of the flour of each impurity from that of wheat flour, the detrimental effects on the color of the bread made from such flour mixtures are very noticeable. (See Table IV.)

MILLING AND BAKING TESTS OF WHEAT CONTAINING IMPURITIES.

TESTS WITH ADMIXTURES OF VARIOUS PERCENTAGES OF EACH IMPURITY.

Table IV gives the results of milling and baking tests with samples of wheat containing certain percentages of the so-called inseparable impurities—rye, corn cockle, kinghead, and hairy-vetch seed. These data are the averages of tests covering three years with rye, kinghead, and corn cockle, with the exception of the tests with 5 per cent and 10

per cent of corn cockle, in which instances tests were made for one year only, and the results obtained in the experiments with hairy vetch are the averages of tests covering two years.

TABLE IV.—*Milling and baking tests of clean wheat and of wheat containing different percentages of rye, corn cockle, kinghead, and hairy vetch.*

Sample description.	Milling yield.			Water absorption.	Volume of loaf.	Score.		Quantity of wheat required per barrel of flour.		Remarks concerning—	
	Bran.	Shorts.	Flour.			Texture of loaf.	Color of crumb.	Bushels.	Pounds.	Crumb.	Dough.
	P.ct	*P.ct*	*P.ct*	*P.ct*	*C.c.*						
Clean wheat (check)	12.5	14.7	71.4	58.0	2,510	94	96	4	34	Creamy	
Wheat with rye:											
1 per cent	11.9	16.5	70.0	57.3	2,410	94	95	4	40	do	Elastic.
2 per cent	11.9	15.9	71.2	57.4	2,430	93	94	4	35	Creamy gray	
3 per cent	12.3	16.1	70.7	57.3	2,440	91	93	4	37	Slightly gray	
5 per cent	12.7	16.3	70.0	57.3	2,440	90	92	4	40	Gray	Fairly elastic.
10 per cent	12.9	16.5	70.0	57.9	2,370	90	92	4	40	do	
Clean wheat (check)	11.7	15.4	71.8	58.2	2,565	94	97	4	33	Creamy	Elastic.
Wheat with corn cockle:											
1 per cent	14.8	13.6	70.0	58.1	2,500	93	95	4	40	Creamy gray	Fairly elastic.
2 per cent	16.0	12.9	69.7	57.4	2,470	90	90	4	41	Gray	
3 per cent	15.7	12.9	70.4	57.7	2,220	86	87	4	38	Very gray	(1).
Clean wheat (check)	12.8	14.1	70.3	62.3	2,765	95	96	4	39	Creamy	Elastic.
Wheat with corn cockle:											
5 per cent	14.1	15.5	70.1	60.9	1,750	80	82	4	40	Very gray	(2).
10 per cent	16.5	13.1	69.3	59.4	910	50	70	4	43	do	(2).
Clean wheat (check)	12.5	14.7	71.4	58.0	2,510	94	96	4	34	Creamy	
Wheat with kinghead:											
1 per cent	13.0	15.3	70.2	57.8	2,445	93	88	4	39	Very gray	Elastic.
2 per cent	13.9	15.7	69.4	57.8	2,450	92	83	4	42	do	
3 per cent	14.3	16.8	67.6	57.9	2,400	89	79	4	50	do	
5 per cent	14.6	20.2	63.3	57.9	2,350	86	70	5	11	Dirty gray	Fairly elastic.
10 per cent	16.2	20.5	61.5	57.8	2,240	80	50	5	19	do	
Clean wheat (check)	11.4	15.5	71.3	58.0	2,450	95	96	4	35	Creamy	Elastic.
Wheat with hairy vetch:											
1 per cent	14.1	14.4	69.7	57.9	2,115	88	92	4	41	do	(3).
2 per cent	13.2	12.9	71.2	57.8	2,015	83	90	4	35	Yellow	(3).
3 per cent	12.8	14.6	71.2	58.2	1,940	78	85	4	35	do	(4).
5 per cent	12.7	14.3	70.7	58.8	1,835	69	79	4	37	Very yellow	(5).
10 per cent	13.4	15.0	70.2	56.3	1,605	63	68	4	39	do	(6).

[1] Fairly elastic, irritating to hands.
[2] Sticky and "runny;" very irritating to hands.
[3] Fairly elastic; odor and flavor of vetch.
[4] Slightly sticky and "runny;" odor and flavor of vetch.
[5] Sticky and "runny;" odor and flavor of vetch.
[6] Short and "runny;" strong odor and flavor of vetch.

A study of Table IV brings out the detrimental effects which the added impurities had on the milling and baking qualities of the wheat. For convenience of discussion the factors of importance from the commercial standpoint may be grouped under two headings, viz, milling quality and baking quality.

MILLING QUALITY.

The amount of flour which can be obtained from a bushel of wheat is of prime importance to the miller, since it is the most valuable mill product. Therefore, any impurity that reduces the yield of flour obtained in milling wheat, or that lowers the quality of the flour, has a direct bearing on the milling value and should receive careful consideration in grading wheat.

The admixture of kinghead seed in wheat greatly reduced the yield of flour, the reduction being especially evident with an increased amount of this impurity, while the addition of different percentages of rye, corn cockle, and hairy-vetch seed did not so materially reduce the amount of flour obtained.

BAKING QUALITY.

One of the prime requisites of flour is that it have good baking qualities, that is, produce a large loaf having good texture and color of crumb, and in addition have the power of absorbing and retaining a large amount of water. Housewives demand a flour having a white or creamy color. Any factor, therefore, which in any way injures the baking qualities of flour, such as reducing the size of the loaf or lowering the color or texture of the bread, should necessarily be considered in placing a valuation on flour and consequently on the grade of wheat from which the flour was milled.

EFFECTS OF IMPURITIES IN WHEAT ON QUALITIES OF FLOUR AND BREAD.

The presence of rye in wheat has a detrimental effect on the loaf volume, and when more than 3 per cent of this ingredient is added the color and texture of the bread will be noticeably injured. The effects of the addition of such impurities as corn cockle, kinghead, or vetch to wheat are much more detrimental in character than where rye is added, as shown in the greater reduction in the size of loaf and the decidedly lower scores given the color and texture of the bread.

With an increased percentage of corn cockle there was a very decided reduction in the loaf volume, with a consequent injurious effect on the texture. In mixing the dough an irritation of the skin of the hands was noticed with the flour milled from wheat containing 3 per cent of corn cockle, with a decided increase in the amount of the irritation when a larger amount of corn cockle was added.

The amount of water absorbed was also considerably less in the tests with flour from wheat containing more than 3 per cent of corn cockle than in the check test with pure wheat flour. When more than 3 per cent of either corn cockle or vetch seed was added to the wheat and made into flour, the dough was "runny" and sticky. In the tests with 3 per cent and 5 per cent admixtures of hairy vetch, there was an apparent increase in the percentage of water absorption as compared with the check sample. However, the remarks concerning the effect on the dough in this connection indicate that an excessive amount of water had been added to the flour, resulting in a "runny" and sticky dough. A smaller amount of water was added to the flour from the 10 per cent mixture of vetch in an attempt to improve the consistency of the dough, but even then it was short and somewhat "runny." A strong and disagreeable odor and flavor of vetch was very noticeable in the bread made from flour of hairy-vetch mixtures.

In these tests with the different impurities described there seemed to be a very close relation between the effects produced on the loaf volume and on the texture of the crumb. Where the volume was greatly decreased, as shown in the results of the tests with corn cockle, a compact loaf of bread with very small pores was obtained, while in the tests with kinghead and rye the pores were much larger and very irregular in shape. Evidently the strength of the gluten was greatly injured by the presence of flour from these various impurities, especially when added in considerable quantities, and corn cockle in large amounts seemed to destroy practically all fermentation.

Figures 5 and 6 graphically illustrate the injurious effects of rye, hairy vetch, kinghead, and corn cockle, on the milling and baking qualities of straight flour made from wheat containing these impurities. The results of the milling and baking tests in this connection are given in Table IV, and the discussion of these results is given on page 11.

Plate I is a reproduction of photographs of bread baked from flour obtained in milling samples of wheat which contained different percentages of rye, corn cockle, kinghead, and hairy vetch showing the detrimental effects of these impurities upon the baking qualities of flour.

TESTS WITH A 10 PER CENT ADMIXTURE OF EACH IMPURITY.

MILLING TESTS.

Table V gives the results of milling tests with samples of wheat containing 10 per cent admixtures of rye, corn cockle, kinghead, and hairy-vetch seed. These samples were milled into three grades of flour—patent, first clear, and second clear. The addition of 10 per cent of kinghead resulted in a great reduction in the yield of total flour, while there was scarcely any difference in the flour yields obtained from the admixtures of rye and corn cockle compared with the check sample of clean wheat. In this experiment but one milling test was made with each admixture and with the clean wheat. In the test with the 10 per cent admixture of hairy vetch, where three grades of flour were made, there was an apparent increase of 1 per cent of total flour over that of the check sample. Previous tests with hairy vetch indicated that this impurity had little, if any, effect on the flour yield, and the result of this one test with a 10 per cent admixture of hairy vetch would be within the limits of variation, especially since in several tests with check samples of this lot of wheat, milled as straight flour in connection with other tests made in 1913, there was a range of 1.5 per cent in the flour yields obtained, the maximum yield being 71 per cent.

With the exception of the test with rye, the amount of patent flour obtained from the samples containing impurities was noticeably less

than in the check test with clean wheat, and the percentage of the lower grades of flours was correspondingly increased. This fact is of great importance in placing a valuation on wheat which contains any considerable amount of these objectionable impurities, for a reduction in the yield of high-grade flour that can be obtained is a financial loss to the miller, and the grade of such wheat should be lowered according to the percentage of admixture of the impurity.

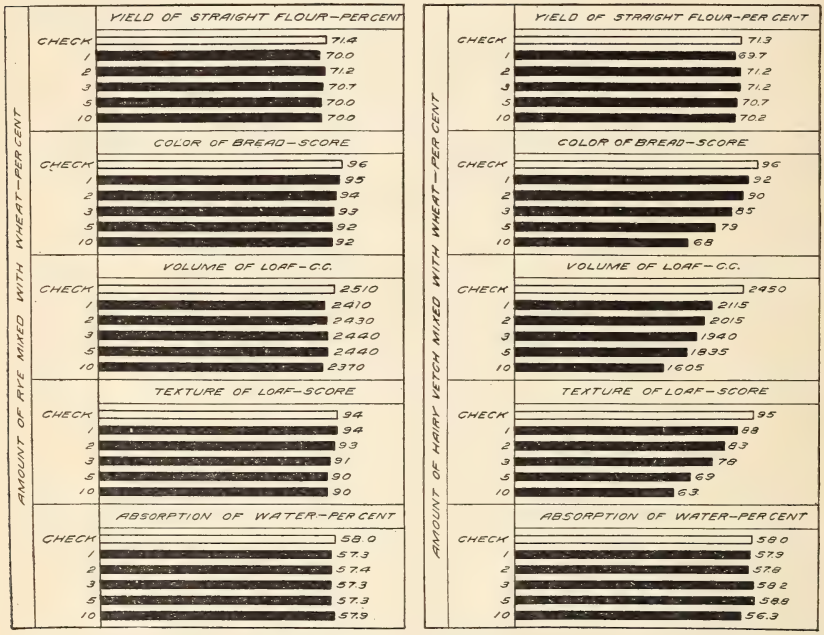

FIG. 5.—Diagram showing the results of the milling and baking tests of straight flour milled from wheat containing various percentages of rye and hairy vetch.

TABLE V.—*Milling tests of clean wheat and of wheat containing 10 per cent admixtures of rye, corn cockle, kinghead, and hairy vetch, milled into three grades of flour.*

Description of sample.	Moisture after tempering.	Bran.	Shorts.	Total flour.	Total flour made.			Quantity of wheat used per barrel of flour.		Color effects on flour.
					Patent.	First clear.	Second clear.	Bushels.	Pounds.	
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*			
Clean wheat (check)	14.9	14.7	13.5	69.5	76.5	19.5	4.0	4	42	White.
With 10 per cent—										
Rye	14.6	14.6	13.8	69.3	77.2	18.2	4.6	4	43	Slightly gray.[1]
Corn cockle	14.5	14.3	15.2	69.2	74.1	21.8	4.1	4	43	Bluish tint and black specks.[2]
Kinghead	14.9	18.9	20.3	60.4	71.2	24.3	4.5	5	24	Gray.[3]
Hairy vetch	15.0	13.7	13.3	70.5	74.8	22.4	2.8	4	38	Yellow.[3]

[1] Most evident in second clear. [2] Very injurious to all grades. [3] Injury evident in all grades.

BAKING TESTS.

Table VI gives the results of baking tests with flour milled from samples of wheat containing 10 per cent admixtures of rye, corn cockle, kinghead, and hairy vetch. These results are interesting, especially when correlated with the milling results given in Table V. The greatest injury of rye is seen in its effects in the second-clear flour, where the scores for the color and texture of the crumb were materially lowered. More second-clear flour was obtained from the test with rye than from the tests with any of the other impurities.

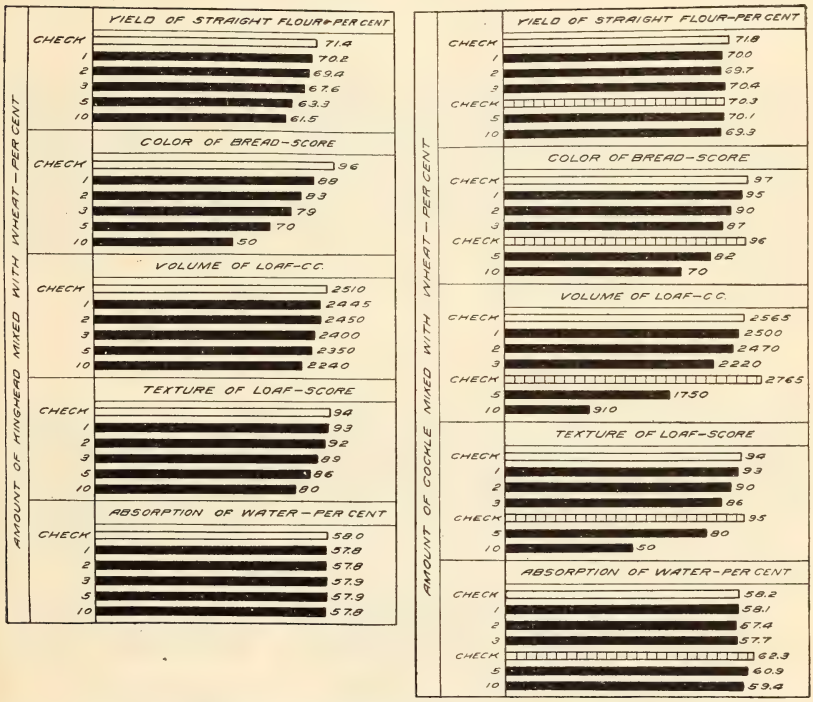

FIG. 6.—Diagram showing the results of the milling and baking tests of straight flour milled from wheat containing various percentages of kinghead and corn cockle.

Corn cockle was well distributed in all three grades of flour, as shown by the exceedingly detrimental effects for all factors given.

Even though the amount of kinghead in each grade of flour was small, the injurious character of this impurity was especially noticeable in the color of the crumb and the texture of the loaf.

That the flour from hairy-vetch seed was well distributed in all three grades of flour is evidenced by the deleterious effects on volume, color, and texture of the loaf. As in the tests where the one grade, straight flour, was made, rye seemed to have a less injurious effect on the baking qualities in these tests with three grades of flour than did corn cockle, kinghead, and vetch.

TABLE VI.—*Baking tests with patent, first-clear, and second-clear flour, milled from clean wheat and from wheat containing 10 per cent admixtures of rye, corn cockle, kinghead, and hairy vetch.*

Description of sample.	Water absorption.	Volume of loaf.	Score.		Remarks.	
			Color of crumb.	Texture of loaf.	Crumb.	Dough.
PATENT FLOUR.						
	P. ct.	*C. c.*				
Clean wheat (check)	62.4	2,670	95	94	Creamy gray	
With 10 per cent—						
Rye	59.7	2,485	95	95	Creamy	
Corn cockle	58.5	1,200	86	55	Gray	(1).
Kinghead	62.4	2,705	53	84	Dirty gray	Slightly "runny."
Hairy vetch	60.9	1,720	72	74	Very yellow	(2).
FIRST-CLEAR FLOUR.						
Clean wheat (check)	61.5	2,180	86	85	Gray	
With 10 per cent—						
Rye	59.4	2,177	78	85	Dirty gray	
Corn cockle	55.6	900	66	50	do	(1).
Kinghead	62.1	2,250	50	85	do	"Runny."
Hairy vetch	62.1	1,590	55	70	Dark yellow	(3).
SECOND-CLEAR FLOUR.						
Clean wheat (check)	62.4	1,882	83	88	Gray	
With 10 per cent—						
Rye	61.2	1,735	58	70	Dirty gray	
Corn cockle	55.3	810	45	50	Black	(1).
Kinghead	62.6	2,020	50	80	Dirty gray	"Runny."
Hairy vetch	61.8	1,420	50	60	Dirty yellow	(4).

[1] Sticky and "runny"; irritating to hands.
[2] Short and slightly "runny"; strong odor of vetch.
[3] Short and slightly "runny"; very strong vetch odor.
[4] Short and "runny"; very strong vetch odor.

The comparative results of the baking tests of patent, first-clear, and second-clear flour milled from wheat samples containing 10 per cent admixtures of rye, corn cockle, kinghead, and hairy vetch, as

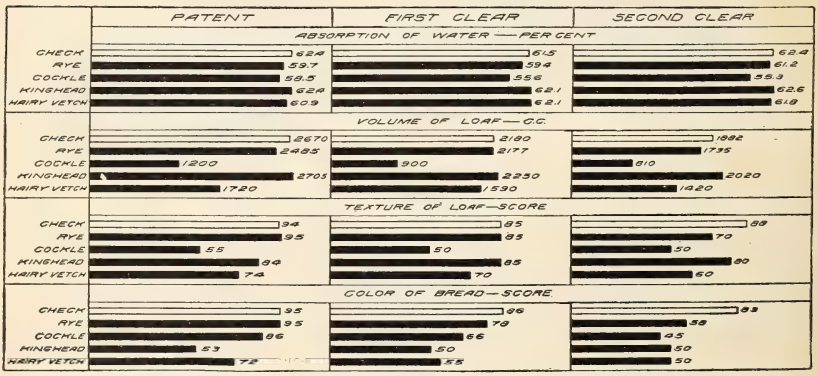
PATENT
FIRST CLEAR
SECOND CLEAR
ABSORPTION OF WATER — PER CENT
CHECK 62.4 61.5 62.4
RYE 59.7 59.4 61.2
COCKLE 58.5 55.6 55.3
KINGHEAD 62.4 62.1 62.6
HAIRY VETCH 60.9 62.1 61.8
VOLUME OF LOAF — C.C.
CHECK 2670 2180 1882
RYE 2485 2177 1735
COCKLE 1200 900 810
KINGHEAD 2705 2250 2020
HAIRY VETCH 1720 1590 1420
TEXTURE OF LOAF — SCORE
CHECK 94 85 88
RYE 95 85 70
COCKLE 55 50 50
KINGHEAD 84 85 80
HAIRY VETCH 74 70 60
COLOR OF BREAD — SCORE
CHECK 95 86 83
RYE 95 78 58
COCKLE 86 66 45
KINGHEAD 53 50 50
HAIRY VETCH 72 55 50

FIG. 7.—Diagram showing the results of baking tests with patent, first-clear, and second-clear flour milled from wheat containing 10 per cent admixtures of rye, corn cockle, kinghead, and hairy vetch.

given in Table VI, are shown diagrammatically in figure 7. The presence of corn cockle in flour very perceptibly lessens the percentage of water that will be absorbed, and both corn cockle and hairy vetch

FIG. 1.—Loaves from clean wheat (*a*) and from wheat containing admixtures of rye: *b*, 1 per cent; *c*, 2 per cent; *d*, 3 per cent; *e*, 5 per cent; *f*, 10 per cent.

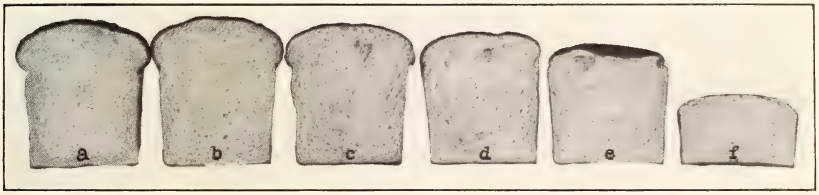

FIG. 2.—Loaves from clean wheat (*a*) and from wheat containing admixtures of corn cockle: *b*, 1 per cent; *c*, 2 per cent; *d*, 3 per cent; *e*, 5 per cent; *f*, 10 per cent.

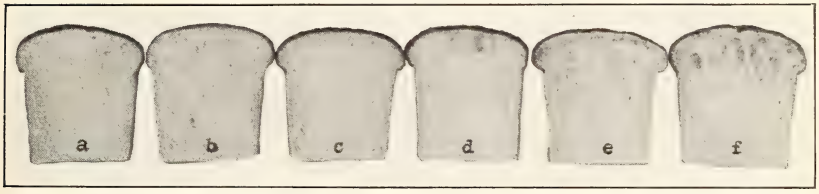

FIG. 3.—Loaves from clean wheat (*a*) and from wheat containing admixtures of kinghead seed: *b*, 1 per cent; *c*, 2 per cent; *d*, 3 per cent; *e*, 5 per cent; *f*, 10 per cent.

FIG. 4.—Loaves from clean wheat (*a*) and from wheat containing admixtures of hairy-vetch seed: *b*, 1 per cent; *c*, 2 per cent; *d*, 3 per cent; *e*, 5 per cent; *f*, 10 per cent.

CROSS SECTIONS OF LOAVES OF BREAD OBTAINED IN CONNECTION WITH THE MILLING AND BAKING TESTS WITH SAMPLES OF WHEAT CONTAINING VARIOUS PERCENTAGES OF RYE, CORN COCKLE, KINGHEAD, AND HAIRY VETCH. THE RESULTS OF THESE TESTS ARE GIVEN IN TABLE IV.

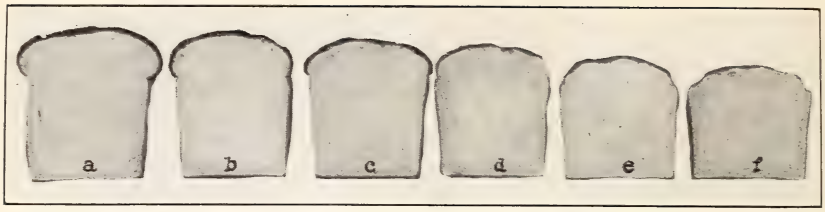

FIG. 1.—Effects of 10 per cent admixture of rye in wheat: *a*, Patent flour (check); *b*, patent flour (10 per cent rye); *c*, first-clear flour (check); *d*, first-clear flour (10 per cent rye); *e*, second-clear flour (check); *f*, second-clear flour (10 per cent rye).

FIG. 2.—Effects of 10 per cent admixture of corn cockle in wheat: *a*, Patent flour (check); *b*, patent flour (10 per cent corn cockle); *c*, first-clear flour (check); *d*, first-clear flour (10 per cent corn cockle); *e*, second-clear flour (check); *f*, second-clear flour (10 per cent corn cockle).

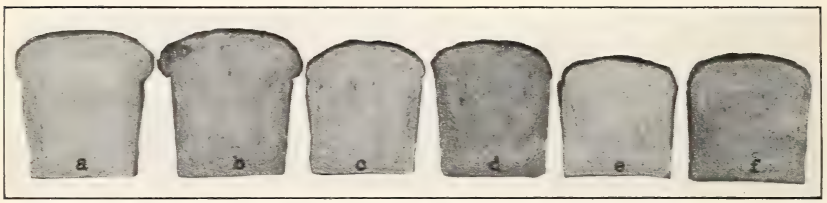

FIG. 3.—Effects of 10 per cent admixture of kinghead seed in wheat: *a*, Patent flour (check); *b*, patent flour (10 per cent kinghead seed); *c*, first-clear flour (check); *d*, first-clear flour (10 per cent kinghead seed); *e*, second-clear flour (check); *f*, second-clear flour (10 per cent kinghead seed).

FIG. 4.—Effects of 10 per cent admixture of hairy-vetch seed in wheat: *a*, Patent flour (check); *b*, patent flour (10 per cent hairy-vetch seed); *c*, first-clear flour (check); *d*, first-clear flour (10 per cent hairy-vetch seed); *e*, second-clear flour (check); *f*, second-clear flour (10 per cent hairy-vetch seed).

CROSS SECTIONS OF LOAVES OF BREAD OBTAINED IN CONNECTION WITH THE BAKING TESTS WITH PATENT, FIRST-CLEAR, AND SECOND-CLEAR FLOUR, MILLED FROM WHEAT CONTAINING 10 PER CENT ADMIXTURES OF RYE, CORN COCKLE, KINGHEAD, AND HAIRY VETCH. THE RESULTS OF THESE TESTS ARE GIVEN IN TABLE VI.

have an especially injurious effect on the loaf volume and texture. The color of the crumb of bread from flour that is milled from wheat containing large amounts of corn cockle, kinghead, and vetch is practically destroyed.

The information given in Table VI and graphically shown in detail in figure 7 is summarized in figure 8. The factors taken into consideration in making up this illustration are the percentage of absorption of water, volume of loaf, and texture and color of loaf for patent, first-clear, and second-clear flour milled from samples of wheat containing 10 per cent admixtures of rye, kinghead, hairy vetch, and corn cockle.

The total scores given the loaves of bread from the samples containing admixtures of impurities are graphically compared with the scores given the check sample of clean wheat, which is used as the standard for comparison, with a rating or score of 100.

In this figure the impurities are arranged in the order of their detrimental influence on the baking qualities, beginning with rye, which, as a whole, had the least injurious effects. Corn cockle is thus shown to be a much more objectionable impurity than any of the others used in the tests, the score in every instance falling far below that of any of the other impurities.

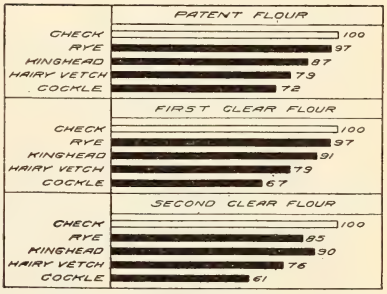

FIG. 8.—Diagram comparing the summarized loaf scores, showing the detrimental effects of 10 per cent admixtures of rye, kinghead, hairy vetch, and corn cockle in wheat on the baking qualities of patent, first-clear, and second-clear flour. Comparison is made with the check test with clean wheat.

Plate II is a reproduction of photographs of bread baked from patent, first-clear, and second-clear flour obtained in milling wheat samples containing 10 per cent admixtures of rye, corn cockle, kinghead, and hairy vetch, and it illustrates the deleterious effects which these impurities have on the baking quality of flour.

TESTS WITH FLOUR BLENDS.

Tests were made with blends of wheat flour and definitely known percentages of flour from rye, corn cockle, kinghead, and hairy-vetch seed, for additional study of the effects of these impurities on the baking qualities. The flour used in these tests was obtained in milling each of the ingredients represented in Table III. The results of the baking tests with blends of wheat flour with each of these impurities are given in Table VII. A blend of 0.5 per cent was in every instance injurious, the detrimental effects being most apparent in the color of

the bread, and with but 1.5 per cent blends the deleterious effects on the color and texture of the bread are especially noticeable.

Blends of rye and corn-cockle flour give a grayish tinge to the crumb, while the addition of kinghead flour results in a loaf with a dirty looking crumb. Hairy-vetch blends give to the bread a yellowish color and a strong and disagreeable flavor and odor characteristic of vetch.

TABLE VII.—*Baking tests with wheat flour blended with different percentages of flour made from rye, corn cockle, kinghead, and hairy vetch.*

Sample description (flour blends).	Water absorption.	Score.		Remarks concerning crumb.
		Texture of loaf.	Color of crumb.	
	Per cent.			
Wheat flour (check)	58.2	93	95	Creamy.
Wheat flour with rye flour:				
0.5 per cent	58.2	90	92	Creamy gray.
0.75 per cent	58.2	89	91	Do.
1.0 per cent	58.2	88	89	Do.
1.5 per cent	57.1	86	85	Do.
Wheat flour (check)	57.9	94	95	Creamy.
Wheat flour with corn-cockle flour:				
0.5 per cent	57.6	93	89	Creamy gray.
0.75 per cent	57.9	91	88	Do.
1.0 per cent	57.9	91	87	Do.
1.5 per cent	57.9	89	85	Do.
Wheat flour (check)	57.9	95	95	Creamy.
Wheat flour with kinghead flour:				
0.5 per cent	57.6	91	86	Dirty gray.
0.75 per cent	57.6	90	80	Do.
1.0 per cent	57.9	89	75	Very dirty gray.
1.5 per cent	57.4	84	60	Do.
Wheat flour (check)	57.9	92	95	Creamy.
Wheat flour with hairy-vetch flour:				
0.5 per cent	57.4	91	92	Creamy yellow.
0.75 per cent	57.9	90	91	Yellow.
1.0 per cent	57.6	89	90	Do.
1.5 per cent	57.6	86	87	Do.

TESTS WITH WHEAT CONTAINING KINGHEAD SEED.

Table VIII gives a comparison of the results of milling and baking tests of samples of wheat containing kinghead seed, as delivered at a country elevator, with the results of tests of samples of the same wheat from which the kinghead was removed by hand picking. In these tests two samples of spring wheat, one a variety known as Bluestem, with 3.6 per cent of kinghead, and the other a bearded spring wheat known as Velvet Chaff, containing 4.5 per cent of kinghead seed, were each divided into two portions. One part was then milled with the kinghead, while from the other part the kinghead seed was removed by hand picking and the clean wheat milled. The detrimental effects of the presence of this impurity in wheat are seen in the reduced flour yield, a smaller loaf volume, and a considerably poorer crumb texture, while the color score of the loaf is as low as that given bread made from low-grade flour, since the crumb was

dark gray in color. As shown in figure 9, *b*, the pores of the loaf are large and very irregular in shape in the bread made from wheat containing 4.5 per cent of kinghead seed when milled.

TABLE VIII.—*Milling and baking tests with samples of wheat before and after the kinghead seed was removed.*

Description of sample.	Flour yield.	Water absorption.	Volume of loaf.	Score.		Remarks concerning crumb.
				Texture of loaf.	Color of crumb.	
Bluestem wheat:	*Per cent.*	*Per cent.*	*C. c.*			
With 3.6 per cent of kinghead	70.8	62.4	2,365	80	60	Dirty gray.
Free from kinghead	72.6	62.6	2,395	84	86	Gray.
Velvet Chaff wheat:						
With 4.5 per cent of kinghead	70.7	61.2	2,215	75	50	Dirty gray.
Free from kinghead	71.0	61.2	2,325	90	93	Creamy gray.

TESTS WITH WHEAT CONTAINING WILD-VETCH SEED, AS GROWN.

Table IX gives the results of milling and baking tests of two samples of spring wheat obtained by the writer from farmers' granaries. Each sample contained a large amount of wild-vetch seed and represented the crops as grown. Two kinds, or species, of wild-vetch seed were found in these samples. The bulk of the seed was narrow-leaved vetch (*Vicia angustifolia*), and the remainder was the hairy-pod vetch (*Vicia hirsuta*).

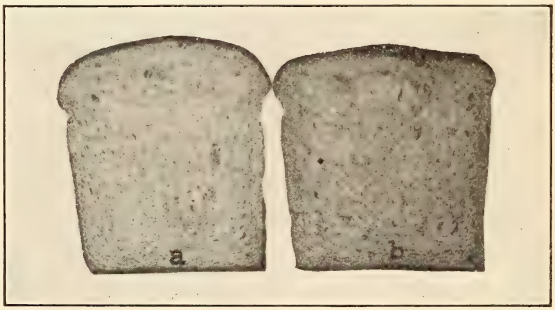

FIG. 9.—Loaves of bread made from wheat free from kinghead seed (*a*) and from wheat containing 4.5 per cent of kinghead seed (*b*).

A comparison is given of the results of tests of wheat containing wild-vetch seed, with the results of tests of the same lot of wheat from which the vetch seed was removed by hand picking. One of the samples contained 17.7 per cent and the other 10.3 per cent of wild-vetch seed after being cleaned and scoured with the mill machinery. The fact that the mill cleaners failed to remove the vetch seed shows that this is practically an inseparable impurity. In fact, the grain buyer for the mill in the locality where this wheat was grown refused to purchase this wheat, which contained such a large amount of wild-vetch seed, claiming that it could not be removed from the grain and that it would be a risky undertaking to make flour from such wheat.

After these samples were cleaned as well as was possible with the small milling separator and scoured twice with the scourer of the

North Dakota Agricultural College mill, they were thoroughly mixed and divided into two portions. One part containing the wild-vetch seed was then milled, while from the other part the wild-vetch seed was removed by hand picking and the clean wheat thus obtained was milled.

The detrimental effects of the presence of wild-vetch seed in wheat as milled are very apparent for all factors given in the tabulation. The injurious effects are noticeably greater in the test with the sample of wheat containing 17.7 per cent of this impurity than in the test with wheat in which there was 10.3 per cent of wild-vetch seed.

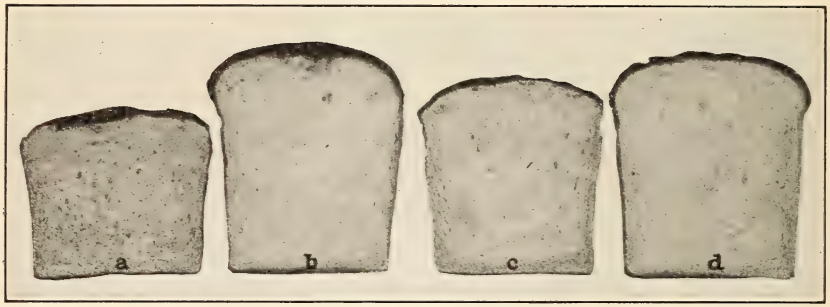

FIG. 10.—Loaves of bread from wheat before and after wild-vetch seed was removed: *a*, With 17.7 per cent vetch seed; *b*, after vetch seed was removed; *c*, with 10.3 per cent vetch seed; *d*, after vetch seed was removed.

TABLE IX.—*Milling and baking tests with samples of spring wheat before and after the wild-vetch seed was removed.*

Description of sample.	Flour yield.	Water absorption.	Volume of loaf.	Score.		Remarks concerning crumb.
				Texture of loaf.	Color of crumb.	
Spring wheat:	*Per cent.*	*Per cent.*	*C. c.*			
With 17.7 per cent of wild vetch.	66.8	53.2	1,765	70	60	Yellowish gray.
Free from wild vetch	68.4	58.2	2,500	95	97	Creamy.
With 10.3 per cent of wild vetch.	66.5	54.4	2,050	80	75	Yellowish gray.
Free from wild vetch	67.6	58.5	2,475	97	98	Creamy.

Figure 10 is a reproduction of a photograph of the loaves of bread baked from flour milled from samples of wheat containing wild-vetch seed. The results of the tests in this connection are given in Table IX.

ANALYSES OF WHEAT, OF THE IMPURITIES, AND OF FLOUR CONTAINING ADMIXTURES.

Samples of patent, first-clear, and second-clear flour obtained in milling samples of wheat containing 10 per cent admixtures of rye, corn cockle, kinghead, and hairy vetch were submitted to the Bureau of Chemistry of the United States Department of Agriculture for chemical analyses, and the results obtained are given in Table X. A study

of this table brings out the following points: (1) The percentage of ash is greater in every instance in the flour containing the impurities than in the pure wheat flour. (2) The percentage of ether extract (fat) of corn cockle and kinghead seed is higher than that of wheat and is likewise greater in all three grades of flour containing these impurities than in the flour from clean wheat. (3) The percentage of protein in the poorer grades of flour (first and second clear) is relatively higher in the flour containing impurities than in the flour from clean wheat, with the exception of the first-clear flour from the 10 per cent rye mixture. (4) The percentage of crude fiber is considerably greater in the first-clear and second-clear flours from the admixture of corn cockle, kinghead, and hairy vetch than in the same grade of flour from pure wheat. (5) The acidity of the first-clear and second-clear flour from corn-cockle seed and vetch-seed mixtures is noticeably higher than that of the same grades of flour from the check sample of clean wheat.

The results of the chemical analyses indicate that the flour from the different impurities was distributed to some extent in all three grades of flour, a larger proportion in most instances going into the first-clear and second-clear flours.

TABLE X.—*Chemical analyses of wheat, rye, corn cockle, kinghead, and hairy vetch and of patent, first-clear, and second-clear flour milled from samples of wheat containing 10 per cent admixtures of these four impurities.*

[Moisture and undetermined, including nitrogen-free extract, not given.[1]]

Description of sample.	Air-dry samples (per cent).							
	Ash.	Ether extract.	Protein.	Crude fiber.	Pentosans.	Invert sugar.	Sucrose.	Acidity as acetic.
Wheat	1.74	1.91	15.44	2.62	7.10	0.14	1.88	0.25
Rye	1.97	1.55	12.19	2.38	10.02	.13	2.69	.27
Corn cockle	3.40	6.01	15.44	6.49	6.02	.32	1.58	.25
Kinghead	2.99	3.33	11.25	44.88	18.97	.14	.60	.73
Hairy vetch	2.84	.83	28.56	7.18	6.15	.02	1.55	.87
PATENT WHEAT FLOUR.								
Wheat (check)	.50	1.16	12.88	.15	2.99	.18	1.12	.12
Wheat with 10 per cent—								
Rye	.58	1.19	12.48	.17	3.31	.25	1.21	.12
Corn cockle	.55	1.40	12.48	.17	3.67	.22	1.26	.11
Kinghead	.60	1.87	13.51	.17	3.35	.30	1.17	.11
Hairy vetch	.76	1.25	14.88	.25	3.75	.20	1.37	.27
FIRST-CLEAR WHEAT FLOUR.								
Wheat (check)	.72	1.60	13.91	.21	3.25	.20	1.45	.16
Wheat with 10 per cent—								
Rye	.77	1.54	13.28	.20	3.87	.21	1.57	.17
Corn cockle	.92	2.32	14.25	.27	3.12	.36	1.46	.25
Kinghead	.79	2.13	14.48	.26	5.82	.30	1.44	.17
Hairy vetch	.91	1.62	14.94	.36	4.31	.26	1.65	.33
SECOND-CLEAR WHEAT FLOUR.								
Wheat (check)	.80	1.86	13.91	.23	3.07	.22	1.65	.18
Wheat with 10 per cent—								
Rye	.95	1.98	14.48	.24	3.86	.25	2.55	.22
Corn cockle	1.20	3.06	16.02	.41	4.10	.38	1.97	.34
Kinghead	.92	2.87	14.88	.43	3.45	.34	1.62	.19
Hairy vetch	1.12	2.09	16.65	.53	3.49	.23	2.00	.39

[1] Chemical analyses by Dr. J. A. Le Clerc, Chief of the Plant-Chemistry Laboratory, Bureau of Chemistry.

SPECIAL CLEANING DEVICES.

SPIRAL CLEANER FOR REMOVING ROUND SEEDS FROM GRAIN.

Machines especially devised for removing round seeds from grain and screenings are advertised in various grain papers and catalogues of firms manufacturing grain-cleaning machinery. One machine used to separate vetch from wheat or rye consists of an upright spiral tube divided into several sections. The grain containing vetch is fed into the top and follows its course down the spiral steel tubes. The round seed travels more rapidly and finally gets into the outer tube or section, while irregularly shaped seeds and lighter matter move less rapidly and are discharged from the openings of the tubes nearer the center. Such machines require very little space, no power (being operated by gravity), and scarcely any watching. The capacity of these machines for cleaning grain thoroughly is very small, as only a few bushels per hour can be cleaned. They are very useful in separating vetch from rye or wheat where clean grain is desired for seeding purposes, but they have insufficient capacity for use in grain elevators or flour mills.

THE COCKLE CYLINDER.

In addition to the grain cleaners usually found in mills for preparing wheat for grinding, specially constructed machines known as cockle cylinders are frequently installed for the purpose of removing from the grain corn-cockle seed and other foreign matter and seeds of similar size and shape.

Although these machines are comparatively inexpensive, a considerable quantity of wheat consisting of broken, small, and shriveled kernels is taken out in removing the corn cockle. This increases the mechanical loss that results from cleaning grain, and a portion of the corn-cockle seed is left in wheat after being cleaned with the cockle cylinder.

MECHANICAL ANALYSES OF CORN-COCKLE SCREENINGS.

Table XI gives the mechanical analyses of four samples of corn-cockle screenings secured from country mills. Sample No. 73719 represents screenings removed in cleaning wheat with the cockle cylinder. Half a pound of screenings was obtained from each bushel of wheat cleaned. Analysis of this sample showed that but 1.3 per cent was corn cockle and 93.6 per cent was wheat. In the other three samples a relatively small percentage of the screenings consisted of corn cockle, while a high percentage was wheat. Sample No. 80994 represents corn-cockle screenings removed by the cleaning machinery in general use in country mills, and the other three samples are screenings removed from wheat with cockle cylinders. Such

screenings are not an entire loss to the miller, since he can often sell them at a fair price for chicken or stock feeding. Corn-cockle screenings are sometimes discriminated against, since it is known that corn-cockle seed contains a poisonous substance known as saponin, or sapotoxin, which is said to have caused trouble in instances where screenings containing a considerable quantity of cockle have been fed to chickens and other animals. Feeding tests have been made by different experimenters with varying results. Some found that young animals were more susceptible and more seriously affected than mature ones, while other experimenters fed varying amounts of corn-cockle seed to different kinds of animals with no apparent symptoms of poisoning. Further experimentation along this line is necessary before any definite conclusions can be drawn concerning the amount of corn-cockle seed that may be fed to different classes of animals before ill effects are produced.

TABLE XI.—*Mechanical analyses of samples of corn-cockle screenings.*

Laboratory No.	Constituents (per cent).														
	Foreign matter.														Wheat (small and broken kernels).
	Other grains.					Weed seeds, etc.								Total.	
	Barley.	Flax.	Oats.	Rye.	Wild oats.	Wild buckwheat.	Mustard.	Cow cockle.	Pigeon grass.	Wild rose.	Garlic.	Chaff, dirt, etc.	Corn cockle.		
66634...	.5	.5	[1] T.	[1] T.	.5	2.5	1.0	0	2.0	2.0	0	0	15.0	24.0	76.0
73590...	[1] T.	.4	[1] T.	0	[1] T.	20.0	1.2	2.4	1.6	.8	0	0	20.4	46.8	53.2
73719...	.4	.4	[1] T.	[1] T.	1.0	1.0	.3	.4	1.0	.6	0	0	1.3	6.4	93.6
80994...	0	0	.2	0	0	0	0	0	0	0	1.2	2.6	11.5	15.5	84.5

[1] T.=trace, the amount found being less than 0.1 per cent.

SUMMARY.

Wheat as grown and as marketed frequently contains certain impurities such as rye, kinghead (great ragweed seed), corn-cockle seed, and wild-vetch seed.

Grain men and millers consider these impurities as inseparable, as they are not easily removed from wheat with the cleaning machinery in general use in grain elevators and flour mills. It is claimed that the presence of these so-called inseparable impurities in wheat as milled injuriously affects the baking qualities of the flour. For this reason wheat containing an appreciable amount of any of these impurities is penalized either by lowering the grade or by reducing the price.

Special experiments were made to ascertain what effects the presence of rye, kinghead, corn cockle, or wild-vetch seed in wheat has on milling and baking qualities.

A sufficient amount of wheat of one variety was purchased to make all the milling tests for each year, in order to have a basis for comparison of all tests with the impurities. Different percentages of each impurity were mixed with wheat samples, which were then milled and baking tests made with the flour.

The results of these tests show that the presence of more than 2 per cent of any of these impurities in wheat as milled has detrimental effects on the milling and baking qualities.

The deleterious effects of rye in wheat are less pronounced than those of corn cockle, kinghead, or vetch seed. If present in wheat in amounts as high as 2 per cent or more, rye lowers the quality of the bread.

Corn cockle seems to have exceedingly injurious effects on the volume, color, and texture of the loaf, and when present in amounts of 3 per cent or more reduces the percentage of water absorption of the flour.

Kinghead in wheat in appreciable amounts materially lowers the flour yield, and the detrimental effects of this impurity in the flour are especially noticeable in the dirty color of the crumb and the coarse, uneven texture of the bread baked from such flour.

Vetch seed in wheat will reduce the size of the loaf and give to the bread a yellowish tinge and a disagreeable odor and flavor characteristic of vetch.

Corn-cockle seed is a more objectionable impurity in wheat than rye, kinghead, or wild vetch, since it contains a poisonous element known as saponin, or sapotoxin, the presence of which is very undesirable in flour or bread.

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